A single facer machine for manufacturing single face corrugated paperboard utilizes an upper corrugating roll and a pressure roll each having its longitudinal axis skewed relative to the longitudinal axis of a juxtaposed corrugating roll to attenuate sound levels during operation.

8 Claims, 7 Drawing Figures
QUICK SINGLE FACER MACHINE

By way of background, the present invention is directed to a single facer machine which is a component of a corrugator. A single facer machine is utilized in the manufacture of single face corrugated paperboard. In a conventional single facer machine, two parallel corrugating rolls have intermeshing flutes which deform a paperboard web medium so as to provide transverse corrugations. An adhesive is applied to the crests of the flutes of the corrugations on the web medium and a liner web is pressed thereon by a smooth surface pressure roll. The pressure roll has its longitudinal axis parallel to the longitudinal axis of the corrugating rolls.

The pressure roll is generally held juxtaposed to the periphery of the lower corrugating roll by yieldable force exerting means such as springs, fluid cylinders, etc. The lower corrugating roll is generally connected directly to the drive by means of a speed reducer and an electric motor. Conventionally, the upper corrugating roll is driven by the lower corrugating roll by way of the meshing of the flutes on the surfaces of the rolls. Conventionally, the pressure roll is driven from the lower corrugating roll by any convenient means such as gearing, friction, etc.

The surfaces of the corrugating rolls are provided with mating, equally-spaced flutes. The flutes are commonly referred to as A, B, C, D, or E fluted depending upon their dimensions and the number of flutes per foot in the corrugated paperboard which is manufactured by them.

The single facer machine of this invention is constructed so as to materially and substantially reduce or attenuate the high sound level of such machines when in operation. This reduction is attained by skewing the longitudinal axes of the upper corrugating roll and the pressure roll relative to the longitudinal axis of the lower corrugating roll. For example, the skew can be about 0.2° to 3° so that more than one flute on each corrugating roll are in contact for transmitting the load. Further, the upper corrugating roll surface is convex with the end diameters smaller than the midpoint diameter when the upper corrugating roll is under load. When a normal load is applied to the ends of the upper corrugating roll, it assumes a concave configuration at the meshed flutes so that as the corrugating rolls rotate under pressure, there is attained the desired contact along the operative length of the meshing flutes. If desired the upper corrugating roll may have a slightly concave surface to achieve the desired contact under light loads.

Hereafter the designers of corrugating rolls of a single facer machine considered it essential to have the longitudinal axes of the rolls parallel. That relationship was probably considered essential since load is transmitted from one roll to the other at the roots of the flutes as compared with gears wherein load is transmitted at the flanks of teeth. It is surprising that only a small skew angle is necessary to reduce noise and that such skewing of one corrugating roll does not materially affect the transmission of a load at the roots of the flutes on the corrugating rolls.

In a conventional single facer machine, the distance between the longitudinal axis of the lower corrugating roll and the longitudinal axis of the pressure roll fluctuates. Such fluctuation is caused by the geometry of the flutes and the manner of contact with the pressure roll thereby creating noise pollution. Thus, the radius to the apex of any flute on the corrugating roll is greater than the radius to a line tangent to two adjacent flute apices. Consequently, the arc of the periphery of the pressure roll alternately moves into the space between two adjacent flute apices and returns or retreats as the apex of the flute moves into a location on the common center line of the lower corrugating roll and the pressure roll.

The periodic variations in the distance between the centers of the lower corrugating roll and the pressure roll results in the flutes on the lower corrugating roll periodically striking the hardened surface of the pressure roll. This rapid impingement produces a level of sound which may be as high as 110 to 120 decibels at high operating speeds. Such high sound levels are deleterious to the hearing acuity of persons nearby and are a source of noise pollution over a wide area.

The single facer machine of this invention is constructed so as to materially and substantially reduce or attenuate the high sound level of such machines when in operation. In the present invention, the single facer machine is provided with a pressure roll adapted to maintain a constant center to center distance between the longitudinal axes of the lower corrugating roll and the pressure roll during most of normal operation. This relationship is attained by skewing the longitudinal axis of the pressure roll. For example, the displacement produced by the skew can be about one or more multiples of the circular pitch of the flutes on the lower corrugating roll. Further, the pressure roll surface is concave with the end diameters greater than the midpoint diameter by an amount so that as these rolls rotate under pressure, there is always contact between an apex of a flute and the periphery of the pressure roll.

In addition to attenuation of noise, the structural interrelationship of the lower corrugating roll and the pressure roll has other advantages. Thus, the frame of the single facer machine can be made from lighter weight and/or cheaper materials as a result of lower bearing loads and vibration forces exerted on the pressure roll.

It is an object of the present invention to provide an apparatus and method to substantially reduce the sound level during operation of a single facer machine.

It is another object of the present invention to provide a quiet single facer machine wherein the longitudinal axis of one corrugating roll and the longitudinal axis of the pressure roll are skewed with respect to the longitudinal axis of the corrugating roll therebetween.

It is another object of the present invention to provide a single facer machine which has lower noise level, lower bearing loads, lower vibration forces, and a frame which can be made from lighter, thinner and cheaper materials.

Other objects will appear hereinafter.

For the purpose of illustrating the invention, there is shown in the drawings a form which is presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown and that such skewing of one corrugating roll does not materially affect the transmission of a load at the roots of the flutes on the corrugating rolls.

FIG. 1 is a side elevation view of a single facer machine in accordance with the present invention, partly in section.

FIG. 2 is a simplified cross-sectional view of a single facer machine at the pressure roll.

FIG. 3 is a schematic illustration of the axial relationship between the corrugating rolls and the pressure roll.

FIG. 4 is a simplified cross-sectional view of the single facer machine at the upper corrugating roll as seen
from the lower corrugating roll.

FIG. 5 is a cross-sectional view of means for supporting the ends of the upper corrugating roll.

FIG. 6 is a diagrammatic showing of the corrugating rolls when the upper roll is loaded.

FIG. 7 is a diagrammatic illustration of the ends of the journals for the corrugating rolls and the pressure roll shown in FIG. 6 with the adjacent ends being in solid lines and the remote ends in phantom lines.

Referring to the drawing in detail, wherein like numerals indicate like elements, there is shown in FIG. 1 a single facer machine designated generally as 10 which may be conventional except as will be made clear hereinafter.

The paperboard web medium 12 to be corrugated passes over an idler roll, and a second idler roll supported by frame 29 in a conventional manner. Thereafter, the web medium 12 passes in contact with a steam shower 14 which provides moisture to render the web medium more pliable for corrugating. Thereafter, the web medium 12 is fed between the upper corrugating roll 18 and lower corrugating roll 20. For the purpose of this disclosure roll 18 is above roll 20. However, those skilled in the art will realize that roll 18 may be alongside or below roll 20.

After being corrugated by rolls 18 and 20, the web medium 12 is retained on the lower corrugating roll 20 by a plurality of crescents 22 at spaced points therealong. A bonding agent, such as starch which may be rendered as an adhesive when gelatinized, is applied to the apices of the corrugations by an applicator roll 24 which rotates partially immersed in the starch solution in an adhesive pan 26.

Force may be exerted on a pressure roll 30 so as to bias it against the lower corrugating roll 20. Such bias on roll 30 may be attained by means of a hydraulic or pneumatic cylinder or mechanical means. Roll 30 is preferably supported on frame 29 by movably mounted arm or link members 34 through which the bias is applied. Members 34 are pivotably supported by pivot pin 33 on the frame 29 of machine 10. Each of the corrugating rolls 18 and 20 are hollow and may be heated by steam, oil or other means. A liner 28 extends around preheater rolls 36 and 38 and then around pressure roll 30. The liner 28 contacts the bonding agent on the flutes and is combined with the corrugated medium 12 into single faced board 35.

The upper corrugating roll 18 is biased against and adjustable toward and away from the lower corrugating roll 20. Thus, to adjust the nip between the rolls 18 and 20 for the passage of the web medium 12 and to apply a load to roll 18 so that it properly contacts roll 20, roll 18 is supported by arm or link members 32 which in turn are pivotably supported by frame 29 at pin 40. Adjustment of members 32 and application of a load to the ends of roll 18 may be attained in any suitable manner, such as by fluid cylinders 37 or mechanical means connected to members 32.

In FIG. 4 there is illustrated the upper corrugating roll 18 supported by said members 32 but out of scale. Line AB in FIG. 3 represents the longitudinal axis of the lower corrugating roll 20, line CD represents the longitudinal axis of the upper corrugating roll 18, and line EF represents the longitudinal axis of the pressure roll 30. The included angle between lines AB and CD or between lines AB and EF may vary between 0.2° and 3° and is referred to herein as angle alpha. This skewed relationship may be attained by a wide variety of structures such as self aligning bearings in a skewed or misaligned bore in members 32 or 34. The effective lengths of the link members 32 and or 34 may not be the same.

In FIG. 5 there is illustrated a embodiment of a bearing support structure 42 in which the ends of the upper corrugating roll 18 may be supported by the frame 29. Pressure roll 30 may be supported in the same manner. The arm or link members 32 have a bore 39 in which bearing support structure 42, containing a self aligning bearing, is mounted. The bearing support structure 42 includes first and second outer races 40, 41.

Outer race 40 is force fit or otherwise secured in bore 39. The outer races 40, 41 have mating curved surfaces. An inner race 44 is force fit or otherwise secured on the journal of the roll 18. Cylindrical roller bearing members 45 are disposed between inner race 44 and outer race 41. By adjusting the position of the members 32, the longitudinal axis of roll 18 will be skewed as desired and described above. The skew of roll 18 is facilitated by the self accommodating nature of the mating surfaces on races 40, 41. The peripheral surface of the upper corrugating roll 18 is convex with the end diameters 46, 48 smaller than the mid diameter 50 by a distance of approximately 0.010 in. to 0.070 inches.

The flutes on upper corrugating roll 18 are helical, and therefore skewed with respect to the longitudinal axis of roll 18 so as to be substantially parallel to the flutes on lower corrugating roll 20. Thus, the skew angle between the flutes on roll 18 and the longitudinal axis of roll 18 is equal to said skew angle alpha. The flute surfaces in contact on rolls 18 and 20 are perpendicular to the direction of travel of web medium 12 whereby the corrugations produced therein will be perpendicular to the side edges of the web 35.

A crown on upper corrugating roll 18 is attained by the different diameters 46, 48, 50. See FIG. 4. When a load is applied to the ends of roll 18 to assure that rolls 18 and 20 are in intimate contact along their entire operative length, the roll 18 is slightly concave at the meshed flutes as shown in FIG. 6. The skew of axes AB and CD assures continuity of contact between more than one flute on each corrugating roll somewhat like the contact attained with meshing helical gears and/or an hour-glass worm and wheel. As is well known, corrugating rolls of a single facer do not transmit loads in the same manner as helical gears. However, the mesh of the flutes on corrugating rolls 18 and 20 will result in quieter operation since there will be progressive contact along the length of a first set of meshed flutes. Such progressive contact is line contact wherein the line has a length less than the length of the flutes. Also, there will be similar contact between a second set of meshed flutes before the first set of flutes lose contact. Specialized and expensive equipment is not needed to apply the flutes on corrugating roll 18. The flutes may be applied to roll 18 using a conventional cutter tool. Since the flutes of roll 18 must be on a radius, the roll 18 must be rotated through an arc which is a function of angle alpha and roll length as the cutter tool moves along the roll 18.

The crown on roll 18 is affected by a wide variety of factors including flute size, corrugating roll diameter, corrugating roll length, pressure between the corrugating rolls, corrugating roll wall thickness, etc. The skew angle alpha is affected by various factors including length of the roll 18. Thus, the skew angle alpha on a
The peripheral surface of the pressure roll 30 is concave with the end diameters 52 and 54 larger than the midpoint diameter 56 by a distance of approximately 0.005 up to 0.060 inches. This is to be compared with a conventional pressure roll where the periphery is a true cylinder or has a crown so that the midpoint diameter is greater than the end diameters.

Each of two adjacent flutes on roll 20 have their apices in contact with the circumference of the pressure roll 30 in a manner so that the distance between the axes AB and CD remain constant during most of normal operation. For example, when a splice between two webs passes through the nip between rolls 20 and 30, roll 30 moves away from roll 20 to accommodate passage of the increased thickness of the webs.

As a result of the present invention, there is an elimination of the impinging effect of the flute apices of the lower corrugating roll 20 on the pressure roll 30 as referred to heretofore in the prior art. The elimination of the impinging effect materially reduces the noise of operation while at the same time materially reduces the vibration to which the pressure roll is subjected. Hence, said members 34, the bearings for the pressure roll 30, and frame 29 may be of lighter weight and gauge materials than utilized heretofore.

Referring to FIG. 6, the roll 18 has journals 60 and 61. Roll 20 has journals 62. Roll 30 has journals 64 and 65. While the axes of rolls 18 and 30 are each skewed with respect to the axis AB of roll 20, as shown in FIG. 3 the axes CD and EF are not parallel to each other. A typical relative position for the end faces of the journals is illustrated in FIG. 7.

As shown in FIG. 7, the centers G and G' at the end faces of the journals 60 and 61 are on one side of a vertical plane containing the axis AB of roll 20. The centers H and H' at the end faces of the journals 64 and 65 are on the other side of said vertical plane. The centers GH define a straight line which passes through the axis AB at the end face of journal 62. Likewise, the centers G'H' define a straight line which passes through the axis AB at the end face of journal 62. This arrangement of axes is preferred since it provides for a better balance of forces.

The skewing of the axes AB and CD results in an attenuation of noise level during operation. The skewing of axes AB and EF results in a further attenuation of noise level. The combined effect of skewing the axis of roll 18 and the roll 30 relative to the axis of roll 20 provides for a quieter single facer machine as compared with only skewing roll 18 or roll 30.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification as indicating the scope of the invention.

1. A method of reducing noise level of operation of a single facer machine wherein the flutes of rotating first and second corrugating rolls are in meshing engagement and have a corrugating medium therebetween, locating the second corrugating roll so that its periphery is juxtaposed to the periphery of a rotating pressure roll with a nip therebetween comprising skewing the pressure roll and first corrugating roll longitudinal axes with respect to the longitudinal axis of said second corrugating roll, forming the flutes on said first corrugating roll such that they are skewed with respect to the longitudinal axis of said first corrugating roll by said skew angle, forming the flutes on said second corrugating roll such that they are parallel to the longitudinal axis thereof, and corrugating a medium between flutes on said corrugating rolls by mating flute surfaces on said corrugating rolls such that the flutes are parallel to each other.

2. A method in accordance with claim 1 including using a first corrugating roll and pressure roll which have a concave surface at the location of contact with the second corrugating roll.

3. A method in accordance with claim 2 including loading the ends of said first corrugating roll to render said surface on the first corrugating roll slightly concave at the meshed flutes.

4. A method in accordance with claim 1 including skewing the axis of said first corrugating roll by an amount so that more than one flute on said first corrugating roll contacts its mating flute on said second corrugating roll.

5. A method in accordance with claim 1 including maintaining the ends of the axes of said rolls in a line which intersects the axis of said second corrugating roll, while the ends of the longitudinal axis of each of said skewed rolls are on opposite sides of a vertical plane containing the longitudinal axis of said second corrugating roll.

6. A single facer machine comprising
a. first and second corrugating rolls having flutes, the flutes on said first corrugating roll being skewed with respect to the longitudinal axis thereof by a skew angle alpha, the flutes on said second corrugating roll being parallel to the longitudinal axis thereof,
b. the longitudinal axis of said first roll being skewed with respect to the longitudinal axis of said second roll by an angle corresponding to angle alpha so that mating flutes on said rolls are generally parallel,
c. a pressure roll juxtaposed to said second roll, the longitudinal axis of said pressure roll being skewed with respect to the longitudinal axis of said second roll by an angle corresponding to angle alpha, the longitudinal axis of said pressure roll being skewed with respect to the longitudinal axis of said first roll by an angle corresponding to twice the amount of angle alpha.

7. A single facer machine in accordance with claim 6 wherein said skew angle alpha is between about 0.25°-3°.

8. A single facer machine in accordance with claim 6 wherein the surfaces of said first corrugating roll and pressure roll which are in contact with said second corrugating roll are concave.